This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Digitized by Google

SD
12
L8
A54
#1

STATE OF LOUISIANA

DEPARTMENT OF CONSERVATION

M. L. ALEXANDER, Commissioner

TECHNICAL PAPER NO. 1

Mud Laden Fluids and Tables on Specific Gravities and Collapsing Pressures

BY

BEN K. STROUD, Supervisor Mineral Division,

Department of Conservation

PUBLISHED BY THE
DEPARTMENT OF CONSERVATION
MARCH 1922

Ramires-Jones Ptg. Co.—54383

Digitized by Google

Digitized by Google

STATE OF LOUISIANA

DEPARTMENT OF CONSERVATION

M. L. ALEXANDER, Commissioner

TECHNICAL PAPER NO. 1

Mud Laden Fluids and Tables on Specific Gravities and Collapsing Pressures

BY

BEN K. STROUD, Supervisor Mineral Division,

Department of Conservation

PUBLISHED BY THE
DEPARTMENT OF CONSERVATION
MARCH 1922

Digitized by Google

Digitized by Google

Forestry Lib.
Dept
Louisiana Dept
Conservation
10-24-1934

INTRODUCTION

The Department of Conservation has recently been conducting a series of experiments to determine weights of oil field muds, cements and other materials for possible use in drilling wells.

The laboratory work was done under direction of F. P. Shayes, Engineer for the Minerals Division, first at the machine shop of the Louisiana Oil Refining Corporation and later at the laboratory of the Huber Carbon Company at Monroe, La. Many helpful suggestions were offered by Mr. R. C. Stewart and Mr. Ran Hewett of the Texas Company, Mr. Clyde M. Bennett of the Louisiana Oil Refining Corporation, Mr. H. W. Price of the Huber Carbon Company, Mr. J. H. Bowles, Consulting Engineer, and others.

Digitized by Google

Digitized by Google

Mud Laden Fluids

The use of mud laden fluid has long been recognized as being a very necessary adjunct in rotary drilling, both for muddling operations and in holding down heavy pressures not controllable with clear water. We find, however, that drillers are given to overestimating the weights of muds used. They go by the consistency of the mud fluid rather than by its actual weight. A mud is considered by them to be "heavy" when it is so thick that the pumps handle it with difficulty, regardless of what its actual weight in pounds per gallon may be.

Muds mixed from a shale or a shaly clay may be of such consistency that they can hardly be pumped and yet their weights may not run over ten (10) pounds to the gallon. (Pure water weighs 8.33 pounds to the U. S. Gallon.) This is instanced by the following: A sample of Bethany, La., gas field mud was shown to several drillers. They called it "14 lb. mud", whereas its actual weight was only ten lbs. 6 oz. per gallon. A second sample from the Monroe field weighed 14 lbs. 6 oz. and was too thick to pump—the drillers called it an "18 lb. mud". Both samples were judged by consistency and not by weight. The important thing in controlling wells is **weight** of fluid. The ideal mud laden fluid is that fluid which gives a much relatively greater weight in column than clear water, but at the same time is fluid enough (i. e. "thin" enough) to prevent the gas from aerating or "working" on the fluid in such a way as to lighten it that the column will be expelled from the well. Thick muds are subject to this aerating action and for this reason their use in heavy pressures has not been satisfactory.

Drillers should frequently weigh samples of mud on the derrick floor and from different depths, at the same time noting the thickness of the horizons. Such data will be invaluable for future reference. Surface clays should also be located and accurately weighed, so that operators may know just where to put their hands on mud making materials.

There is a nation wide shortage of pure clays, and whenever same are found, either above or below the surface, their presence should be carefully noted, as their value may be considerable.

Digitized by Google

In order for the reader to form some idea of relative weights or specific gravities (1) we give the following:

Material	Specific Gravity	Wt. per cu. ft.	Wt. per gal. lbs.	Wt. of col. in lbs. per sq. in. per ft.	Wt. of col. 1000 ft.	Condition
Water	1.	62.35	8.3356	.434	434	wet
Salt	2.3	143.40	19.09	.99	990	dry
Clay-pure	2.3	143.40	19.09	.99	990	dry
Brine	1.2	74.82	9.96	.52	520	wet
Cement	3.2	197.03	26.56	1.37	1370	dry
Clay mud	1.8	112.23	14.94	.78	780	wet
Light oil field mud	1.1	68.59	9.13	.47	470	wet
Heavy oil field mud	1.6	99.76	13.28	.69	690	wet
Iron Oxide (deydrated)	4.9	305.52	40.67	2.11	2110	dry
Galena	7.5	467.63	62,15	3.23	3230	solid
Lead Concentrates	2.3	143.40	19.09	.99	990	dry

(1) Specific Gravity of a substance is its weight compared with the weight of an equal bulk of pure water. A specific gravity of 1.8 means that the substance is 1.8 times heavier than an equal bulk of pure water.

As above noted, the specific gravity of pure clay is 1.8. The muds used in drilling in our North Louisiana fields are much below this figure and some of them were found to have a specific gravity as low as 1.1, or slightly above that of water. The average oil field mud will probably weigh 11 to 12 pounds per gallon and where heavy gas pressures are encountered these weights are not sufficient. For these reasons, the following laboratory experiments were made in the hope that suitable materials might be found which, when mixed with water, would give added weight and at the same time remain fluid enough to be easily handled with pumps.

CEMENT

Cement has a Sp. Gr. of 3.16 to 3.3 and is about twice as heavy as oil field muds. Herewith is given analysis of a typical oil field cement.

Digitized by Google

ANALYSIS OF A TYPICAL CEMENT

CHEMICAL AND PHYSICAL TESTS
METHOD: AS SPECIFIED BY THE AMERICAN SOCIETY FOR TESTING MATERIALS

CHEMICAL ANALYSIS

Silica	SiO_2	21.50%
Oxide of Iron	Fe_2O_3	2.43%
Oxide of Aluminum	Al_2O_3	7.63%
Oxide of Lime	CaO	63.70%
Oxide of Magnesia	MgO	1.76%
Sulphur Trioxide	SO_3	1.24%
Ignition loss	Loss	1.75%

SPECIFIC GRAVITY 3.122		TENSILE STRENGTH					
Fineness 100M-95.5 200M-74.62		Neat			Sand		
		Age	Lbs. Sq. In.	Ave.	Age	Lbs. Sq. In.	Ave.
		24 Hrs.	391		24 Hrs.		
Percent Neat	23.3 Sand 9.6		380				
		7 Days	398	389			
Set-Initial	2 Hours 27 Minutes		860		7 Dys.	356	
			840			375	
Temperature	Air 73 F° Water 70°		842	847		381	364
		28 Dys.	955		28 Dys.	450	
Soundness on	Steam 5 H Sound		970			470	460
Average	Boil 3 Hrs. Sound		953	959		460	
	Air 28 D "	3 Mos.	984		3 Mos.	467	
Sample	Water 28 D "		996	990		482	474

(Note that 90% of total set is attained within the first seven days. Also that the tensile strength of a neat cement sample is greater than the 1 to 3 sand mixture.)

The following cement companies have forwarded analyses of their product to this office: The Trinity Portland Cement Co. of Dallas, Texas, the Atlas Portland Cement Co. of Birmingham, Ala., the Oklahoma Portland Cement Co. of Oklahoma City and the Lehigh Portland Cement Co. of Allentown, Pa.

From analyses received, all the above brands would be expected to give good results in oil field work and may be safely used in cementing wells.

Cement being heavier than drilling muds, it was thought that the set of the cement could be destroyed by the addition of certain proportions of mud. Samples were accordingly mixed in 30-70, 50-50 and 65-35 ratios, the first figures indicating percentages of cement. Contrary to our expectation, in every case a firm set was made and the samples when dried were found to be very light in weight and on being reground and mixed with water they did not show their former weights. Another sample of 50% cement and 50% mud was stirred continuously for 6 hours and after being allowed to stand for a further 3 hours a firm set was made.

These experiments show conclusively that:

(1) Cement will set when mixed with mud, and that cement mud mixtures cannot be used as mud laden fluids

Digitized by Google

unless kept in constant motion; even then, there is strong likelihood that the mixture might plug the drill stem or water holes in the bit, or cause the drill stem to stick. Pure cement, of course, can be used in killing a well and is an excellent material therefor, but the idea in the present experiments was to develop a flud that could be safely used where it is not desired to kill the well. (A column of cement 2000 ft. deep will exert a pressure of about 1900 lbs. per sq. inch while a 14 lb. mud at the same depth will give a pressure of a little over 1300 lbs.)

(2) Lead Sulphides and cement were mixed and left to stand. While the initial set was materially delayed, the sample finally attained a good set. Gypsum, a calcium sulphate, also delays the set and free sulphur gas has the same tendency. High temperatures of 115 degrees Fahrenheit or over will, on the other hand, hasten the set. In the above cases the tensile strength of the cement will not be as great as would be a pure water cement mix, and could not be expected to stand the strains that the latter mix would stand.

It is generally believed that cement will not set in salt water. That this opinion is erroneous was proved by the following: A sample of water in which was dissolved two (2) pounds of salt per gallon of water was mixed with a cement having a reported initial set of 2 hrs. 30 min. The initial set was delayed to 7 hrs. 20 min. but the sample finally made a good firm set.

Oil is also generally supposed to prevent cement from setting. If the cement is thoroughly mixed with water and then immersed in oil it will eventually set. Oil standing in wells will not destroy the set of a batch of well mixed cement, as is generally supposed. Cement mixed directly with oil, however, will not set and such a fluid could be used in handling high pressures if heavy mud laden fluid is not at hand, but the cement will settle out of the oil if left to stand and should be kept in circulation when in the well.

In connection with the above remarks it is always well to mix samples of cement with the water to be used in the well in order to determine time of set of cement. The character of the water, the make-up of the cement and temperatures at setting point all have their influences on the initial set and may delay it as much as 15 to 20 hours. It may be here stated that the practice of testing for water shut off within 24 or 48 hours after cementing casing carries the risk of damaging the set and consequent failure to make a successful job.

LEAD CONCENTRATES

Galena or Lead Sulphide has a specific gravity of 7.3. It was thought that the lead concentrates when mixed and ready to pump would have about the same specific gravity as the dry samples and that a mixture of 20 to 25 pounds per gallon could be made. Samples of the concentrate were ob-

Digitized by Google

tained from the Federal Lead Co. of Flat River, Missouri, and experiments made with them, wet and dry. We found that the concentrates are in a finely divided state and each particle being coated with a film of oil (used for concentration purposes), that the mixtures were all too light to be practicable. Furthermore, the concentrates settled out of the water rapidly, a very objectionable feature for well work. The samples weighed 19 pounds per gallon with fresh water and 20 pounds per gallon with salt water (2 pounds of salt per gallon of water) but the latter was too thick to pump. When thinned out, the concentrates settled rapidly and experiments were then discontinued. The cost of $60 per ton f. o. b. Flat River, Missouri, would make this an expensive material for use in Louisiana wells.

IRON OXIDE

Iron Oxide, Fe_2O_3 is the highest form of oxidation of iron. It is commonly used in paints and is known for its protective qualities because of its oxidized state. For this reason it would make an excellent protective to casings where left in the well. It is in a finely divided form when dry and when wet becomes a sticky clay-like mass. In its finely divided state it should have great penetrative qualities. By consulting the tables, some idea may be gained of its weight in column. From experiments made, Iron Oxide will not cake or settle out of the water and a mixture of 16 pounds per gallon of an oxide containing 85% iron was found to be very fluid and easily handled by the pump. A sample of five (5) pounds was mixed with 1 quart 2 gills of water and was found to weight 15 pounds per gallon. A second sample mixed with 7½ gills of water was found to weigh 16 pounds 6 oz. per gallon. A third sample was mixed with salt water (2 pounds of salt per gallon of water) and weighed 16 pounds 14 ounces per gallon All these mixtures were very fluid and pumps could have handled them easily. The price quoted by two different firms is $30.00 and $38.20 per ton f. o. b. Shreveport, respectively, in car lots of 25 tons or more. Names of these firms will be furnished upon application to the Department.

Suppose a 10 or 11 pound mud is already mixed at the well and it becomes necessary to get a 14 or 15 pound mud at short notice. By adding a few pounds of Iron Oxide per gallon the weight could be quickly brought up to requirements and the mud would give no trouble in settling out. Such a mud could be held in reserve pits and used for later wells.

Operators sometimes forget that mixing and hauling mud costs money; some of this cost might be saved in the use of an Iron Oxide mud. It could be landed at unloading points in car lots and then hauled to the warehouse or directly to the well, thus saving considerable time and expense.

In the Monroe field, operators have often spent days trying to overcome gas and water pressures. The gas pressures are about normal, that is, they are about equal in pressure to

Digitized by Google

that of a column of water at the same depth and it is often necessary to use fluids of relatively greater weights than clear water to effectively control them. In many parts of the field it is exceedingly difficult to get materials necessary for heavy muds, because of the shaly character of the formations, and a supply of Iron Oxide kept in readiness against the time of entering a high pressure gas pay would be excellent insurance. Its use would be fully justified where wells give signs of becoming uncontrollable, or where heavy pressures are expected.

Iron Oxide is also a valuable aid in stopping small leaks in collars or joints of casing. By rigging up a small lubricator on top the casing, the red paint oxide is easily introduced inside the casing and can be depended upon to seal effectively the small leaks that are otherwise difficult to stop.

There are many wells in our gas fields today which are junked or in bad condition because of the driller's inability to hold down the gas pressure with mud laden fluids used. A sudden rush of gas may collapse the casing or stick the drill stem and cause later complications which would result in leaving a part of the stem in the hole and perhaps a damaged water string. The success or failure of the well depends upon the use of a fluid heavy enough to control the gas beyond any doubt or question. We believe that Iron Oxide will fully answer this purpose.

Below is given a table showing pressures and weights at various depths, using varying proportions of Iron Oxide:

TABLE

Wt. per Gal.	Gal. per 1000'		Wt. of Iron Oxide in tons in Column of 1000'		Amt. Iron Oxide lbs. per gal.	Pressure lbs.. per sq. in. for 2000'
	6⅝"	8"	6⅝"	8"		
11	1788 ft.	2618 ft.	3	4.5	3½	1142
12	" "	" "	4	5.8	4½	1246
13	" "	" "	5.3	7.8	6	1350
14	" "	" "	7.1	10	8	1454
15	" "	" "	8.9	13	10	1560
16	" "	" "	10.7	15.5	12	1660
17	" "	" "	12.5	18	14	1764

Fifteen (15) pound mud from Iron Oxide is very fluid. It can be easily made and will probably handle any pressures encountered. The Oxide, however, should contain at least 80% Iron to reach the above weights.

THE USE OF CALCIUM CARBONATES IN MUD LADEN FLUIDS

There has lately come into use in California a new mud fluid for use in drilling wells. The Petroleum Age of issue Volume 8, No. 14, page 19, describes it. The material is precipitated calcium carbonate, CaCo3, a waste by-product of the beet sugar refineries of that section. In effect, so far as

Digitized by Google

weight goes, it would be just the opposite of a heavy mud laden fluid as it has a low specific gravity and its value would be very small for heavy pressures.

The precipitated calcium carbonate is very plastic and it is claimed by the users that a mixture of "lime-mud," so-called, has a great penetrative effect and makes a good wall plaster. The color of the mud being light, the faintest showings of oil may be detected and the mud is easily removed by washing from the hole. In calling the above to the attention of Louisiana operators, it is thought that a similar material might be found in this State, which at small expense may be as effective in making a lime-mud as the calcium carbonate.

COLLAPSING PRESSURES AND CAPACITIES OF TUBES

The use of cement in excluding water from oil or gas strata is too well known to require further comment here, but operators generally are not so well informed regarding pressures at which any given casing or pipe will collapse. The following tables have been very kindly furnished by the Engineering Department of the National Tube Co., Pittsburg, Pa.

Digitized by Google

COLLAPSING PRESSURES AND CAPACITIES PER LINEAR FOOT OF DIAMOND BX. CASING

SIZE	DIAMETERS		THICKNESS	WEIGHT PER FOOT COMPLETE	COLLAPSING PRESSURE PER SQUARE INCH	EQUIVALENT WATER COLUMN	WATER COLUMN WITH			CAPACITY PER LINEAR FOOT	CAPACITY PER LINEAR FOOT
	EXTERNAL	INTERNAL					SAFETY FACTOR OF 3	SAFETY FACTOR OF 2½	SAFETY FACTOR OF 2		
INCHES	INCHES	INCHES	INCHES	POUNDS	POUNDS	FEET	FEET	FEET	FEET	GALLONS	CUBIC FT.
4½	4.750	4.082	.334	16.000	4708	9416	3139	3766	4708	.679	.090
4¾	5.000	4.500	.250	12.850	2948	5896	1965	2358	2948	.826	.110
4¾	5.000	4.408	.296	15.000	3745	7490	2497	2996	3745	.792	.106
5⅜	6.000	5.352	.324	20.000	3294	6588	2196	2635	3294	1.169	.156
6¼	6.625	6.049	.288	20.000	2382	4764	1588	1906	2382	1.493	.200
6¼	6.625	5.921	.352	24.000	3219	6438	2146	2575	3219	1.430	.191
6¼	6.625	5.855	.385	26.000	3651	7302	2434	2921	3651	1.399	.187
6¼	6.625	5.791	.417	28.000	4069	8138	2713	3255	4069	1.368	.183
6⅝	7.000	6.456	.272	20.000	1982	3964	1321	1586	1982	1.701	.227
6⅝	7.000	6.336	.332	24.000	2725	5450	1817	2180	2725	1.638	.219
6⅝	7.000	6.276	.362	26.000	3096	6192	2064	2477	3096	1.607	.215
6⅝	7.000	6.214	.393	28.000	3480	6960	2320	2784	3480	1.575	.211
6⅝	7.000	6.154	.423	30.000	3851	7702	2567	3081	3851	1.545	.207
7⅝	8.000	7.386	.307	26.000	1940	3880	1293	1552	1940	2.226	.298
8¼	8.625	8.017	.304	28.000	1669	3338	1113	1335	1669	2.622	.351
8¼	8.625	7.921	.352	32.000	2151	4302	1434	1721	2151	2.560	.342
8¼	8.625	7.825	.400	36.000	2633	5266	1755	2106	2633	2.498	.334
8¼	8.625	7.775	.425	38.000	2885	5770	1923	2308	2885	2.466	.330
8¼	8.625	7.651	.487	43.000	3508	7016	2339	2806	3508	2.388	.319
9⅝	10.000	9.384	.308	33.000	1283	2566	855	1026	1283	3.593	.480
10	10.750	10.054	.348	40.000	1420	2840	947	1136	1420	4.124	.551
10	10.750	9.960	.395	45.000	1799	3598	1199	1439	1799	4.047	.541
10	10.750	9.902	.424	48.000	2032	4064	1355	1626	2032	4.000	.535
10	10.750	9.784	.483	54.000	2508	5016	1672	2006	2508	3.906	.522
11	11.750	11.000	.375	47.000	1380	2760	920	1104	1380	4.937	.660
11	11.750	10.772	.489	60.000	2221	4442	1481	1777	2221	4.734	.633
11⅝	12.000	11.384	.308	40.000	839	1678	559	671	839	5.287	.707
12½	13.000	12.438	.281	40.000	507	1014	338	406	507	6.312	.844
12½	13.000	12.360	.320	45.000	747	1494	498	598	747	6.233	.833
12½	13.000	12.282	.359	50.000	1007	2014	671	806	1007	6.155	.823
12½	13.000	12.220	.390	54.000	1214	2428	809	971	1214	6.093	.814
13½	14.000	13.344	.328	50.000	645	1290	430	516	645	7.265	.971
15½	16.000	15.198	.401	70.000	786	1572	524	629	786	9.424	1.260

COLLAPSING PRESSURES AND CAPACITIES PER LINEAR FOOT OF BOSTON CASING

SIZE	DIAMETERS		THICKNESS	WEIGHT PER FOOT COMPLETE	COLLAPSING PRESSURE PER SQUARE INCH	EQUIVALENT WATER COLUMN	WATER COLUMN WITH			CAPACITY PER LINEAR FOOT	CAPACITY PER LINEAR FOOT
	EXTERNAL	INTERNAL					SAFETY FACTOR OF 3	SAFETY FACTOR OF 2½	SAFETY FACTOR OF 2		
INCHES	INCHES	INCHES	INCHES	POUNDS	POUNDS	FEET	FEET	FEET	FEET	GALLONS	CUBIC FT
4¼	4.500	4.216	.142	6.750	1349	2698	899	1079	1348	.725	.096
4¼	4.500	4.090	.205	9.500	2562	5124	1708	2050	2562	.682	.091
4½	4.750	4.460	.145	7.250	1260	2520	840	1008	1260	.811	.108
4½	4.750	4.364	.193	9.500	2136	4272	1424	1709	2136	.777	.104
4¾	5.000	4.696	.152	8.000	1249	2498	833	999	1249	.899	.120
5	5.250	4.944	.153	8.500	1140	2280	760	912	1140	.997	.133
5	5.250	4.886	.182	10.000	1619	3238	1079	1295	1619	.974	.130
5	5.250	4.768	.241	13.000	2593	5186	1728	2074	2593	.928	.124
5	5.250	4.648	.301	16.000	3583	7166	2389	2866	3583	.881	.118
5¼	5.500	5.192	.154	9.000	1041	2082	694	833	1041	1.100	.147
5⅜	6.000	5.672	.164	10.500	983	1966	655	786	983	1.313	.175
5⅜	6.000	5.620	.190	12.000	1359	2718	906	1087	1359	1.289	.172
5⅜	6.000	5.552	.224	14.000	1850	3700	1233	1480	1850	1.258	.168
5⅝	6.000	5.450	.275	17.000	2586	5172	1724	2069	2586	1.212	.162
6¼	6.625	6.287	.169	12.000	825	1650	550	660	825	1.613	.216
6¼	6.625	6.255	.185	13.000	1034	2068	689	827	1034	1.596	.213
6⅝	7.000	6.652	.174	13.000	768	1536	512	614	768	1.805	.241
6⅝	7.000	6.538	.231	17.000	1474	2948	983	1179	1474	1.744	.233
7¼	7.625	7.263	.181	14.750	671	1342	447	537	671	2.152	.288
7⅝	8.000	7.628	.186	16.000	629	1258	419	503	629	2.374	.317
7⅝	8.000	7.528	.236	20.000	1171	2342	781	937	1171	2.312	.309
8¼	8.625	8.249	.188	17.500	520	1040	347	416	520	2.776	.371
8¼	8.625	8.191	.217	20.000	795	1590	530	636	795	2.737	.366
8¼	8.625	8.097	.264	24.000	1267	2534	845	1014	1267	2.675	.358
8⅝	9.000	8.608	.196	19.000	519	1038	346	415	519	3.023	.404
9⅝	10.000	9.582	.209	22.750	458	916	305	366	458	3.746	.500
9⅝	10.000	9.434	.283	30.250	1067	2134	711	854	1067	3.631	.485
10⅜	11.000	10.552	.224	26.750	424	848	283	339	424	4.543	.607
11⅝	12.000	11.514	.243	31.500	417	834	278	334	417	5.409	.723
12½	13.000	12.482	.259	36.500	397	794	265	318	397	6.357	.850
13½	14.000	13.448	.276	42.000	385	770	257	308	385	7.379	.986
14½	15.000	14.418	.291	47.500	367	734	245	294	367	8.481	1.134
15½	16.000	15.396	.302	52.500	338	676	225	270	338	9.671	1.293

NOTE:—Equivalent water column is figured on a basis of two feet to each pound of collapsing pressure due to the fact that the water encountered is often salt water with a higher specific gravity than pure water. Factor of safety of 3 is recommended, and we do not advise a factor of safety of less than 2½

Digitized by Google

COLLAPSING PRESSURES AND CAPACITIES PER LINEAR FOOT OF LINE PIPE

SIZE	DIAMETERS		THICKNESS	WEIGHT PER FOOT COMPLETE	COLLAPSING PRESSURE PER SQUARE INCH	EQUIVALENT WATER COLUMN	WATER COLUMN WITH			CAPACITY PER LINEAR FOOT	CAPACITY PER LINEAR FOOT
	EXTERNAL	INTERNAL					SAFETY FACTOR OF 3	SAFETY FACTOR OF 2½	SAFETY FACTOR OF 2		
INCHES	INCHES	INCHES	INCHES	POUNDS	POUNDS	FEET	FEET	FEET	FEET	GALLONS	CUBIC FT.
4	4.500	4.026	.237	10.980	3179	6358	2119	2543	3179	.661	.088
4½	5.000	4.506	.247	12.742	2895	5790	1930	2316	2895	.828	.111
5	5.563	5.047	.258	14.966	2634	5268	1756	2107	2634	1.039	.139
6	6.625	6.065	.280	19.367	2277	4554	1518	1822	2277	1.501	.201
7	7.625	7.023	.301	23.915	2035	4070	1357	1628	2035	2.012	.269
8	8.625	8.071	.277	25.414	1397	2794	931	1118	1397	2.658	.355
8	8.625	7.981	.322	29.213	1850	3700	1233	1480	1850	2.599	.347
9	9.625	8.941	.342	34.612	1694	3388	1129	1355	1694	3.262	.436
10	10.750	10.192	.279	32.515	863	1726	575	690	863	4.238	.567
10	10.750	10.136	.307	35.504	1089	2178	726	871	1089	4.192	.560
10	10.750	10.020	.365	41.649	1557	3114	1038	1246	1557	4.096	.548
11	11.750	11.000	.375	46.805	1380	2760	920	1104	1380	4.937	.660
12	12.750	12.090	.330	45.217	857	1714	571	686	857	5.964	.797
12	12.750	12.000	.375	50.916	1163	2326	775	930	1163	5.875	.785
14 O.D.	14.000	13.250	.375	56.649	936	1872	624	749	936	7.163	.958
15 O.D.	15.000	14.250	.375	60.802	781	1562	521	625	781	8.285	1.108
16 O.D.	16.000	15.250	.375	64.955	645	1290	430	516	645	9.489	1.269
17 O.D.	17.000	16.214	.393	72.769	617	1234	411	494	617	10.726	1.434
18 O.D.	18.000	17.182	.409	80.659	589	1178	393	471	589	12.045	1.610
20 O.D.	20.000	19.182	.409	89.794	429	858	286	343	429	15.012	2.007

COLLAPSING PRESSURES AND CAPACITIES PER LINEAR FOOT OF SOUTH PENN CASING

SIZE	DIAMETERS		THICKNESS	WEIGHT PER FOOT COMPLETE	COLLAPSING PRESSURE PER SQUARE INCH	EQUIVALENT WATER COLUMN	WATER COLUMN WITH			CAPACITY PER LINEAR FOOT	CAPACITY PER LINEAR FOOT
	EXTERNAL	INTERNAL					SAFETY FACTOR OF 3	SAFETY FACTOR OF 2½	SAFETY FACTOR OF 2		
INCHES	INCHES	INCHES	INCHES	POUNDS	POUNDS	FEET	FEET	FEET	FEET	GALLONS	CUBIC FT.
5 3/16	5.500	5.044	.228	13.000	2207	4414	1471	1766	2207	1.038	.139
5 3/16	5.500	4.892	.304	17.000	3405	6810	2270	2724	3405	.976	.130
6¼	6.625	6.257	.184	13.000	1021	2042	681	817	1021	1.597	.214
6¼	6.625	6.135	.245	17.000	1819	3638	1213	1455	1819	1.536	.205
6¼	6.625	6.041	.292	20.000	2439	4878	1626	1951	2439	1.489	.199
6¼	6.625	5.913	.356	24.000	3271	6542	2181	2617	3271	1.427	.191
6⅝	7.000	6.538	.231	17.000	1474	2948	983	1179	1474	1.744	.233
6⅝	7.000	6.450	.275	20.000	2019	4038	1346	1615	2019	1.697	.227
6⅝	7.000	6.334	.333	24.000	2737	5474	1825	2190	2737	1.637	.219
8¼	8.625	8.097	.264	24.000	1267	2534	845	1014	1267	2.675	.358
8¼	8.625	8.003	.311	28.000	1739	3478	1159	1391	1739	2.613	.349
8¼	8.625	7.907	.359	32.000	2221	4442	1481	1777	2221	2.551	.341
10	10.750	10.192	.279	32.515	863	1726	575	690	863	4.238	.567
10	10.750	10.146	.302	35.000	1049	2098	699	839	1049	4.200	.561
10	10.750	10.050	.350	40.000	1436	2872	957	1149	1436	4.121	.551
12½	13.000	12.338	.322	45.000	761	1522	507	609	761	6.229	.832
12½	13.000	12.278	.361	50.000	1021	2042	681	817	1021	6.151	.822

NOTE:—Equivalent water column is figured on a basis of two feet to each pound of collapsing pressure due to the fact that the water encountered is often salt water with a higher specific gravity than pure water. Factor of safety of 3 is recommended, and we do not advise a factor of safety of less than 2½

NATIONAL TUBE CO.

Digitized by Google

COLLAPSING PRESSURES AND CAPACITIES PER LINEAR FOOT OF ROTARY DRILL PIPE

SIZE	DIAMETERS		THICKNESS	WEIGHT PER FOOT COMPLETE	COLLAPSING PRESSURE PER SQUARE INCH	EQUIVALENT WATER COLUMN	WATER COLUMN WITH			CAPACITY PER LINEAR FOOT	CAPACITY PER LINEAR FOOT
	EXTERNAL	INTERNAL					SAFETY FACTOR OF 3	SAFETY FACTOR OF 2½	SAFETY FACTOR OF 2		
INCHES	INCHES	INCHES	INCHES	POUNDS	POUNDS	FEET	FEET	FEET	FEET	GALLONS	CUBIC FT
4	4.500	4.026	.237	11.151	3179	6358	2119	2543	3179	.661	.088
4	4.500	3.990	.255	11.916	3525	7050	2350	2820	3525	.649	.086
4	4.500	3.962	.269	12.500	3795	7590	2530	3036	3795	.640	.085
4	4 500	3.826	.337	15.000	5105	10210	3403	4084	5105	597	.079
4½	5.000	4.506	.247	12.933	2895	5790	1930	2316	2895	.828	.111
4½	5.000	4.396	.302	15.500	3849	7698	2566	3079	3849	.788	.105
4½	5.000	4.290	.355	18.000	4768	9536	3179	3814	4768	.750	.100
5	5.563	5.047	.258	15.094	2634	5268	1756	2107	2634	1.039	.139
5	5.563	4.955	.304	17.500	3350	6700	2233	2680	3350	1.002	.134
5	5.563	4.813	.375	21.000	4456	8912	2971	3565	4456	.945	.126
6	6.625	6.065	.280	19.507	2277	4554	1518	1822	2277	1.501	.201
6	6.625	5.939	.343	23.500	3101	6202	2067	2481	3101	1.439	.192
6	6.625	5.761	.432	29.000	4266	8532	2844	3413	4266	1.354	.181

NOTE:—Equivalent water column is figured on a basis of two feet to each pound of collapsing pressure, due to the fact that the water encountered is often salt water with a higher specific gravity than pure water. Factor of safety of 3 is recommended, and we do not advise a factor of safety of less than 2½.

NATIONAL TUBE CO.

These tables show conclusively that operators are not using the proper weights of casing for the deeper drilling done in the State. A factor of safety of 2 should never be shaded; in fact, the manufacturers recommend a safety factor of at least 2½. Much casing trouble will be avoided by selection of the right weight of casing for the depth at which the casing is to be set. The tenth column to the right gives the depth to which water may be bailed down in the casing, without danger of collapsing, with a safety factor of 2.

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google